DOCUMENT RESUME

ED 321 888 PS 018 954

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TITLE Beyond "Scaffolding": The Role of Mediation in Preschoolers' Self-Regulation of Model-Consultation with Microcomputer Puzzles.
SPONS AGENCY Maryland Univ., College Park. Dept. of Curriculum and Instruction.
PUB DATE Apr 90
NOTE 41p.; Paper presented at the Annual Meeting of the American Educational Research Association (Boston, MA, April 16-20, 1990).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Cognitive Processes; *Microcomputers; Models; *Preschool Children; Preschool Education; Pretests Posttests; *Problem Solving; Puzzles; *Teacher Influence; *Tutoring
IDENTIFIERS *Mediation; *Self Regulation

ABSTRACT

The effectiveness of specfic dimensions of adult mediation on preschoolers' self-regulation of a model-consultation strategy was evaluated in a microcomputer-based problem-solving task. Two trained tutors taught 61 children who were pretested and randomly assigned to one of four treatments devised to test two factors of mediation: access and analysis of a picture-puzzle model prior to or during problem solving. Tutorial interchanges were designed on the basis of the Vygotskian tenet that effective instruction includes a concern for children's actual and potential developmental levels and occurs through participation with others during problem solving. Measures of self-regulated piece placements, children with self-regulated look-backs, children retrieving pieces after self-regulated look-backs, trials and test time were calculated from three videotaped sessions and used to assess children's self-regulation during treatment and in immediate and delayed posttests. Analyses revealed significant differences for the access and analysis effects in posttests, but only in the delayed posttest for the latter. Significant differences were found for the planned contrast. Children who received the "during access/analysis" treatment were more likely to have self-regulated look-backs and retrieve more pieces from self-regulated look-backs than children receiving the other three treatments, but only in the delayed posttest. Children in the "during access/analysis" treatment also had fewer trials and took longer to complete the puzzle. (RH)

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ED321888

Beyond "Scaffolding": The Role of Mediation in Preschoolers' Self-regulation of Model-consultation with Microcomputer Puzzles

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Paper presented at the Annual Meeting of the American Educational Research Association, Boston, 1990. This research was supported in part, by a grant awarded by the Department of Curriculum and Instruction, University of Maryland. Author would like to thank the Graduate Fellowship Office, University of Maryland for travel support for this presentation. Photo "Courtesy of the Center for Young Children, University of Maryland".

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ABSTRACT

The effectiveness of specific dimensions of adult mediation on preschoolers' self-regulation of a model-consultation strategy was evaluated in a microcomputer-based problem-solving task. Two trained tutors taught 61 children, pretested and randomly assigned to one of four treatments devised to test two factors of mediation, access and analysis of a picture-puzzle model prior or during problem-solving. Children received either a "prior access no analysis", "prior access analysis", "during access no analysis" or "during access analysis" treatment. Tutorial interchanges of treatments were designed from the Vygotskian viewpoint that effective instruction includes a concern for children's actual and potential developmental level, and occurs through participation with others, during problem-solving.

Measures of self-regulated piece placements, children with self-regulated look-backs, children retrieving pieces after self-regulated look-backs, trials and test time were calculated from three videotaped sessions and used to assess children's self-regulation during treatment and in immediate and delayed posttests. A series of analyses of variance with repeated measures and chi-square analyses were performed to validate treatments and to assess the process and effects of the mediation.

Analyses revealed significant differences for the access and analysis effects in posttests, but only in the delayed posttest for the latter. Significant differences were found for the planned contrast; children who received "during access analyses" were more likely to have self-regulated look-backs and retrieve more pieces from self-regulated look-backs than children in the other three treatments, but only in the delayed posttest. They also had fewer trials and took longer to complete the puzzle. Individual strategy differences were analyzed and discussed in relation to mediation.

These findings suggest that children's acquisition of the model-consultation strategy can improve over a short period of time, although not immediately, with culturally-mediated instruction and does not improve solely as a function of practice. The implications of these results for early childhood educators and researchers interested in optimizing children's self-regulation in computer contexts are discussed.

The interchange between tutor and learner may be the most effective instructional setting to teach children of any age, especially young children (Blank, 1973; White, Kaban & Attanucci & Shapiro, 1978). However, tutors differ in their instructional styles, and some styles may be more effective than others (Bee, Van Egeren, Streissguth, Nyman, and Leckie, 1969; Bernstein, 1971, Hess & Shipman, 1968; Laosa, 1980; Steward & Steward, 1973).

Recent studies, guided by Vygotskian theory and the socio-cultural school, have sought to identify specific components of the process of instruction that optimize children's learning in tutorial settings (Arns, 1981; Ellis & Rogoff, 1986; McLane, 1981; Pratt, Cowan & Cowan, 1988; Sammarco, 1984; Wertsch & Hickmann, 1987). In this research, theoretical notions such as joint activity, the zone of proximal development (ZPD), inter- to intrapsychological functioning, and self-regulation have provided a conceptual framework for examining how tutors support and extend children's acquisition of problem-solving strategies.

"Scaffolding", a metaphor currently associated with the ZPD, is a process of guided practice in problem-solving which consists of an adult controlling elements of a task that are initially beyond the learner's capacity (Wood, Bruner & Ross, 1976). The scaffolding process however, has not been grounded in a general theory of cultural transmission or communicational interchange of higher order skills (Griffin & Cole, 1984). Scaffolding may become confused and equated with increments of assistance instead

of qualitative shifts that lead to new ideas that go beyond scaffolding (Tharp & Gallimore, 1990). Guided participation toward self-regulation includes the constructive role of social-cultural factors (Rogoff & Gardner, 1984), a wide range of verbal and nonverbal mediation, temporal-spatial-directional coordinates of task interpretation (Rommetveit, 1979), and instruction within the context and analysis of a specific task.

Of special interest in the present study are tutorial interactions in a picture puzzle-solving task in which children must use the higher order executive strategy of model-consultation for efficient puzzle solutions. In the prototypical task, children are shown a pictorial model of the completed puzzle. Customary cues such as the shapes of puzzle pieces may not be available; consequently, children need to consult the model for information about the placement of the pieces. Because research supports children under 5 years of age do not spontaneously use a model-consultation strategy (Wertsch, McNamee, McLane, & Budwig, 1980), the experimental task used in the present study provided an opportunity to examine components of tutors' instructional behaviors that might facilitate acquisition and internalization of this strategy. Furthermore, researchers have found young children have difficulty scanning visual arrays and models without adult mediation (Olson, 1970).

Neo-Vygotskian research has been of great importance in understanding the origins of children's strategies; however, much of the research using the Vygostkian paradigm has been

correlational, yielding partial assessments of the strategy acquisition. Often, the tutorial exchanges studied are those of mothers and their children; thus it has not been possible to separate tutorial strategies from characteristics of the learner or from pre-existing relationships between tutor and child. It also has not been possible to examine the durability of instructional effects or to test its generalizability to a computer context. Even though computer-presented tutorials have been criticized for their inability to replicate the sophisticated processes employed by human tutors (Dreyfus, 1986), few researchers have examined the effects of tutor interventions in a computer context (Fox, 1988).

The present study addressed these issues. It used a microcomputer-presented problem-solving task to identify two dimensions of mediated instruction; its timing of model-consultation or "access mediation" and its informativeness or "analysis mediation", on young children's acquisition of a model-consultation strategy with pictorial puzzle solving.

Access mediation involved teacher suggestions for accessing or looking back at the model. These suggestions occurred either prior to problem-solving or during problem-solving; "prior access" versus "during access". Analysis mediation involved "analysis" versus "no analysis" of the puzzle model. In analysis, the teacher gave a pictorial analysis including perceptual features of objects and their spatial relations using indexing. The combination of these dimensions resulted in four

treatment groups: "prior access no analysis", "prior access analysis", during access no analysis", and "during access analysis". Two posttests, one immediately after instruction and another, one week later were designed to determine whether these factors were related to children's short and long term performance.

First, it was hypothesized that subjects receiving "during access" mediation would be more likely to display self-regulated model-consultation than children receiving "prior access" mediation. Second, it was hypothesized that children would be more likely to display self-regulated model-consultation with "analysis" mediation than with "no analysis" mediation. Third, an a priori hypothesis stated that children who received a combination of "during access and analysis" mediation would be more likely to display self-regulated model-consultation than children in all other treatments.

METHOD

Subjects

Sixty-one children, 34 girls and 27 boys, enrolled in a university child care and research center participated in the study. The children's ages ranged from 3.6 to 5.6 years with a mean age of 4.6 years. The children came from five different day care classes: 56% were in full-day care and 44% were in half-day care. Children were from middle-class, highly-educated families of diverse ethnicities. All children had received prior

computer experiences through the center's microcomputer-integrated curriculum and were accustomed to using computers in classrooms and research rooms.

Experimental Setting and Materials

Training and testing were conducted in two research rooms, each equipped with a videotape recorder, a wall-mounted video camera, a ceiling-suspended microphone, an Apple II+ microcomputer and color monitor. Responses were made via the keyboard using highlighted keys. The software, Peanuts Picture Puzzlers (Random House/McGraw Hill, 1984), was unfamiliar to the children.

Design

This experimental study employed a randomized pretest-posttest factorial design and permitted a 2 (access mediation; prior problem and during problem access) x 2 (analysis and no analysis) x 2 (immediate and delayed posttests) repeated measures analysis.

Teachers

Teachers were both female early childhood graduate students; one was a masters level student and the other a doctoral student. Each teacher served as a tutor in each of the four experimental treatments and were blind to the research hypotheses. Children were randomly assigned to treatments, teacher and turn-taking order. Teachers taught approximately the same amount of boys and girls in each treatment.

Procedures

Teacher Training. Teachers received training and practice in the application of the pretests, treatments and posttests. Teacher training included seven total hours of instruction with the researcher in computer program procedures, a review of the scripts, role-playing with the experimenter, and a study of video-taped scenes from piloting. An additional hour was allotted for practice with children not in the study. Intervention guidelines and techniques for responding to children's learning efforts were provided in a manual.

Instruction and Interventions. Teachers' behaviors during treatment were guided by scripts that described and illustrated the behaviors appropriate for each treatment. The optimal mediational treatment outlined teachers' usage of individually tailored feedback responsive to children's active collaboration and interactive learning. The scripts are derived primarily from the work of Vygotsky (1978), Wertsch et al. 1980; Wood et al. (1976), and Wood, Wood & Middleton (1978), and took over two years to develop. Teacher behaviors drawn from these sources were used to define four treatments (See Table 1). Treatment validity was then established through confirmation of these behaviors.

Insert Table 1 about here

Sessions. Teachers visited with children during group time where they were introduced by the classroom teacher who informed the class that each child would have a turn to make some puzzles on a microcomputer with one of the teachers.

Children were trained and tested individually in three 15 to 20 minute sessions. The first session included instructions on the program manipulanda and a pretest. From an initial sample of 75 children, pretesting eliminated 9 children (mean = 7.5 look-backs, range = 4 - 13). Five additional children were excluded for their inattentiveness to the task. Two days later in the second session, children received one of four treatments and an immediate posttest. One week later in the third session, children received a delayed posttest.

Measures

Three measures are often used in model-consultation studies to assess children's self-regulated behavior. One measure is the child's correct placement of pieces without adult mediation. However, when first learned, higher order strategies may not always lead immediately to correct placements and alternative problem-solving strategies may do as well. A better, and more direct, measure of strategy acquisition is whether a child actually consults the model. Nevertheless, a child might access the model and not use the information it provides. A third measure of strategy acquisition is thus whether a look-back is followed by a correct placement. Several other measures provide useful indications of the children's willingness to engage in

the task. If, for example, some groups take more time to complete the puzzle, or make more attempts to place pieces, these differences would have to be taken into account when evaluating children's puzzle-solving behavior and the process of self-regulated strategy acquisition.

Coding

Teacher Behaviors Assessed During Treatment. A category coding scheme was developed from the script to analyze the videotaped tutoring sessions. Frequency scores were tabulated for teacher behaviors described in Table 1.

Treatment Homogeneity and Validation. Treatment validation measures were designed to confirm that the groups actually received the scripted treatments. The investigator coded all of the tutoring sessions including both teacher and child behaviors. A female graduate student, who was blind to the research hypotheses, and the researcher independently coded a random selection of 40% of the total sample. Overall agreement percentages between the coder and researcher was .99.

Children's Learning Behaviors. Children's learning behaviors during treatment and posttests are described in Table 2.

Insert Table 2 about here

Interobserver Agreement for Posttests. The investigator was the principal coder and scored all immediate and delayed posttest

sessions. An independent coder coded a random selection of 26% of the total sample for each posttest. The overall agreement between the two coders for posttest measures was .99. For the post hoc measure of individual strategy differences, agreement was .91.

RESULTS

The results are organized into five major sections: tests for covariate effects, treatment validation, children's behaviors assessed during treatments, children's behaviors assessed in posttests, and post hoc analyses. Teacher and child behaviors assessed during treatment provided a dynamic assessment of children's learning in the process of mediation, whereas posttests analyses addressed its effects.

Tests for Covariate Effects

Although children were randomly assigned to treatments, inspection of pretest data indicated that children in the "during access analysis" treatment had fewer look-backs at pretest condition than children in all other groups (See Table 3).

Insert Table 3 about here

In order to test for pretest differences, two analyses were conducted on pretest look-back scores. First a chi-square analysis was performed on pretest scores of one or two look-backs to investigate whether treatments differed in the percentage of

children who had used the model-consultation strategy on the pretest. The main effect for access was not significant (Chi (1,N = 61) = 1.08). A significant main effect was obtained for analysis (Chi (1,N = 61) = 3.74, $p < .05$), indicating that the treatments with "no analysis" had twice as many children with pretest look-backs as the treatments with "analysis". Significance was not found in the planned contrast of "during access analysis" versus other treatments (Chi (1,N = 61) = 1.58). Second, a regression analysis performed on pretest scores yielded no significant covariate effects with immediate or delayed posttest look-backs. Regression analysis also revealed no significant covariate effects for age and Peabody Picture Vocabulary Test scores on performance.

Treatment Validation

Table 4 presents the treatment means and standard deviations of teacher behaviors. As can be evidenced, treatment means are highest for the "during access analysis" treatment on all teacher behaviors except for positive reinforcements and assistance. This is a reflection of the optimal mediation scripted for this treatment. Standard deviations of teacher behaviors indicate children in the "during access analysis" treatment received varied amounts of mediation reflecting the individually tailored and contingent mediation they received.

Insert Table 4 about here

Analyses of variance (ANOVA) were performed on each teacher behavior measure to investigate treatment differences. The data demonstrates that teachers administered treatments according to scripts. Children received distinctive types and amounts of teacher mediation. Significant differences were found between treatments for teacher behaviors as expected.

Child Learning Behaviors Assessed During Treatment

Means, standard deviations, proportions and results from analyses for child learning behaviors assessed during treatment are presented in Table 5.

Insert Table 5 about here

Children's learning behaviors were not reflected in significant differences in the amount of self-regulated piece placements. A marginally significant difference was found between the prior and during access treatment for self-regulated look-backs (Chi (1,N = 61) = 2.75, p = < .09). For those children who used the look-back information at all, children in the "during access" treatment used it more often and retrieved correct pieces after self-regulated look-backs more often than the "prior access" treatment (Chi (2,N = 61) = 6.96, p < .03).

Children's Behaviors Assessed in Posttests

The independent performance of children in two posttests is presented in Tables 6 through 11.

Insert Table 6

As depicted in Table 6 significance was not found for self-regulated piece placements for the access main effect, analysis main effect or for the planned contrast.

Significant differences were found for self-regulated look-backs in the immediate posttest for the access main effect (Chi (1,N = 61) = 10.35, p = < .001). Children who had self-regulated look-backs were twice as likely as those who did not to have been in the "during access" treatment for the immediate posttest. The hypothesis that children will have a greater likelihood of consulting the model when exposed to "analysis" mediation than to "no analysis" mediation was not supported in the immediate posttest.

Significant differences were revealed in the delayed posttest for the access main effect (Chi (1,N = 61) = 8.66, p < .003). As presented in Table 7, children who had self-regulated look-backs were twice as likely than those who did not to have been in the "during access" treatment. As predicted, in the delayed posttests, there was a significant main effect for self-regulated look-backs in analysis (Chi (1,N = 61) = 3.78, p < = .05), and significant interaction effect for the planned contrast (Chi (1,N = 61) = 8.40, p <.003).

Insert Table 7

The hypothesis that children receiving "during access" mediation would be more likely to retrieve pieces after self-regulated look-backs than those receiving "prior access" was supported in the immediate posttest (Chi (2,N = 61) = 11.31, $p < .003$). Significance was also found in the delayed posttest, (Chi (2,N = 61) = 8.66, $p < .01$) (See Table 7). Children who retrieved pieces after self-regulated look-backs were more likely than those who did not to have been in the "during access" treatment. Although children in the "analysis" treatment retrieved pieces more often after self-regulated look-backs than children in the "no analysis" treatment, the difference was not significant for the analysis effect (Chi (2,N = 61) = 3.91). Significance was found for the planned contrast (Chi (2,N = 61) = 8.51, $p < .01$). Children in the "during access analysis" treatment were more likely to retrieve pieces after self-regulated look-backs than children in all other treatments.

Post Hoc Analyses

To further explore children's self-regulation of the model-consultation strategy and to investigate the interrelationships among measures, a series of post hoc analyses were performed. First, ANOVA's were performed on the measures of test time and trials. Second, intercorrelations between self-regulated piece placements, test time, trials, and self-regulated look-backs were

investigated. Third, a three-way chi-square analysis was performed to examine for individual strategy differences. Fourth, strategy types were then examined in relation to self-regulated piece placements, test time, and trials using ANOVA.

Test time and Trials. Treatments did not significantly affect the speed of problem-solving or motivation as indexed by the number of problem-solving efforts. Test time and effort were the same on the average for children regardless of mediation, however large standard deviations revealed differences within groups (See Tables 8 & 9).

Insert Tables 8 & 9 about here

Table 10 shows the Pearson product-moment correlations among four measures: self-regulated piece placements, test time, trials and self-regulated piece placements in the immediate and delated posttest. The analyses shows relationships which demonstrate that children who took more time to complete the puzzle had fewer self-regulated piece placements or received more adult assistance in the immediate and delayed posttests, ($-.50$, $p < .001$ and $-.63$, $p < .001$, respectively). Children who had fewer trials also took longer to complete the puzzle in both posttests ($-.40$, $p < .000$ and $-.37$, $p < .001$). However, children who took more time, also had significantly more self-regulated look-backs in both posttests ($.32$, $p < .01$ and $.67$, $p < .001$) (See Table 10).

Insert Table 10 about here

Individual Strategy Differences. In the next series of analyses, three-way chi-square analyses were conducted to assess differences of treatments in relation to three individual strategy differences: trial and error, mixed and model-consultation. The results of these analyses, displayed in Tables 8 and 9, reveal that children exhibited significantly different approaches in their attempts at puzzle-solving.

Significant main effects were revealed in the immediate posttest for access main effect (Chi (2,N = 61) = 9.78, $p < .007$), for analysis main effect (Chi (2,N = 61) = 5.15, $p < .07$) and for the interaction effect of "during access analysis" versus all other treatments (Chi (2,N = 61) = 9.82, $p < .007$).

On the delayed posttest, children in the "during access", "analysis" treatments were more likely to be model-consultation and mixed strategy types whereas; children in the "prior access" and "no analysis" were more likely to be trial and error users. On the delayed posttest, chi-square analyses revealed significance for the access main effect (Chi (2,N = 61) = 12.10, $p < .002$), for the analysis main effect (Chi (2,N = 61) = 9.61, $p < .008$), and for the interaction effect (Chi (2,N = 61) = 13.78, $p < .001$).

A trial and error strategy permitted children to place pieces without receiving adult assistance. Thus, the

analyses demonstrates that the measure of self-regulated piece placement for this particular study, was not a sensitive measure of children's self-regulated model-consultation in the immediate or delayed posttest.

ANOVA's were then conducted to test for differences in strategy types as related to self-regulated piece placements, test time and trials in posttests (See Table 11).

Insert Table 11 about here

Significant differences were found for all measures in the immediate posttest: self-regulated piece placements ($F(2,58) = 3.6$, $p < .03$), test time ($F(2,58) = 5.88$, $p < .005$ and trials ($F = (2,58) = 3.45$, $p < .03$). The model-consultation strategy users had fewer self-regulated piece placements than the trial and error mixed strategy users (means = 8.4 versus 12.3 and 13.7, respectively). Test time was almost twice as long for the model-consultation users as it was for the trial and error and mixed strategy users (means = 8.4 versus 4.5 and 4.79, respectively). They also had fewer trials than the trial and error and mixed users (means = 33.4 versus 56.0 and 49.4, respectively).

Significant differences were found in the delayed posttest: self-regulated piece placements ($F(2,58) = 3.75$, $p < .03$), test time ($F(2,58) = 21.25$, $p < = .0001$), and trials ($F(2,58) = 3.96$, $p < .02$). Model-consultation strategy users took longer to complete the puzzle in the delayed posttest, ($M = 10.5$) than in

the immediate posttest (M = 8.4).

Summary of Results

Effects of access mediation. First, the hypothesis that a significant difference would be found in "during access" mediation was supported in both posttests for the measures of children with self-regulated look-backs and children who retrieved pieces after self-regulated look-backs. The measures of self-regulated piece placements, test time, and trials of piece insertion were not found to be significant in posttests. However, significance was found when these same measures were tested in relation to individual strategy differences.

Effects of analysis mediation. Second, the hypothesis that children who received analysis mediation would be more likely to improve than children who received none was supported, but only on the self-regulated look-back measure and only in the delayed posttest. Nonsignificant results showed a tendency in the direction hypothesized. Significant effects were found for the analysis factor when pretest self-regulated look-backs were tested as a covariate. This may have accounted for the nonsignificant differences found for the analysis factor in the posttests. Significant differences were not found on the measures of self-regulated piece placements, test time, and trials of piece insertion but were found when these same measures were tested with individual strategy differences.

Effect of "during access analysis" treatment. Third, support was found for the a priori hypotheses most central to

this study: children who received "during access analysis" treatment were more likely to consult the model than children in the other three treatment groups, but only in the delayed posttest. They were more likely to retrieve pieces after self-regulated look-backs, but only in the delayed posttest.

SUMMARY AND DISCUSSION

Several conclusions can be made from this research. First, children's acquisition of self-regulation of model-consultation is enhanced with "during access analysis" mediation, not immediately but over a short period of time. Given the brevity of the 15-20 minute mediation, and the fact that the children were working with a stranger, the improvements made by children in this study are educationally significant. The composition of children's behaviors differed markedly between groups and more so on the delayed posttest. A longer intervention time involving more mediational sessions might have resulted in more immediately significant findings.

Second, the integration of adult perceptual and spatial descriptions to children's specific actions during problem-solving with indexing, assessments and repetitions of the strategic significance of accessing the model proved to be effective tools in luring and convincing children to continue with the strategy despite its initial difficulty, in structuring the activity and in enhancing the transition to independent functioning. The poor performance demonstrated by the "prior

access no analysis" control group suggests that improvement cannot be explained solely as a function of practice.

Third, this research opened a window into children's thinking and apprenticeship in strategy usage with a microcomputer-presented problem-solving task. Children's understanding of the strategic significance of looking at a model as a cue in puzzle-solving did not necessarily occur in an all or none fashion and instead passed through a transitional zone itself. Those children attempting to utilize the model-consultation strategy may not have fully grasped the concept and were attempting to move through the ZPD. Tharp et al. (1990) identify this performance as stage 2 of the ZPD; the child carries out a task without assistance from others but the performance is not fully developed or automized.

The majority of children in all other treatments were trial and error users in both posttests. Groping for some task solution children found out quickly that a trial and error approach would also allow one to finish the puzzle without teacher assistance. Although a trial and error approach required more trials, it took a shorter period of time. As Schauble (1989) notes, all children are natural problem-solvers and often seek to find a solution rather than a strategy.

Perhaps the mixed strategy users were those children who had rudimentary ideas about the strategic significance of looking and studying a model but abandoned the model-consultation strategy because it took longer and was more difficult to employ.

Fourth, examining patterns of relationships among measures and over time revealed that children found different ways to solve puzzles. Significant differences were found for self-regulated piece placements, test time and trials of piece insertion in relation to individual strategy or solution differences. The relationships among these measures suggests that self-regulated piece placements as a measure of self-regulated model-consultation is task specific. Researchers should be cautious about confusing a single performance measure with the internalization of a strategy. Multiple measures examined in relation to one another and over time may better serve researchers in their attempts to understand young children's self-regulation of a culturally-mediated strategy.

Implications

This research demonstrated that teachers can adapt and extend children's learning via a computer. With the burgeoning use of microcomputers in early childhood classrooms, this study suggests that human tutors should be integrated with children's learning in microcomputer-based problem-solving activities. The enabling factors of the computer context, both substantive and methodological, have implications for the development of intelligent tutoring systems. Computer-based tutorials that are theoretically-based, motivating, and that offer a context for dialogue may benefit children working with their parents as well.

Although focused on a specific experimental task, setting and subjects, this study exemplified how computer settings can

invite and help create contexts for intellectual "joint reference". Even though not tested specifically in this study, the generalizability of model-consultation as an important problem-solving aid to non-computer contexts has life-long applications (e.g., reading maps, blueprints, assembling a tricycle).

The idea that instruction which moves ahead of development "impels or wakens a whole series of functions that are in a stage of maturation lying in as zone of proximal development" (Vygotsky, 1987, p. 212) has profound implications for educational practice. Assisting children's transitions to competence and independent developmental achievement is one of the major goals of teaching. However, the process and effects of mediation towards self-regulation may be more complex than previous scaffolding research has suggested. Teachers' sensitivity to children's ZPD may be difficult to instruct or measure. Although assisted performance identifies what a child can do with the support of others, teachers have to make judgments about when to assist. Offering assistance while enabling children to feel a locus of control in their learning may be one of the arts of teaching. On the other hand, it may be possible to effectively mediate strategies of mediation.

For teachers and parents, this study presents an example of how mediation and social interaction can support and challenge children's learning with a developmentally appropriate task. For researchers, the study presents a "representative anecdote"

(Olson, 1970) that supports the Vygotskian hypothesis that culture mediates children's developing self-regulation and is thus worthy of further investigation.

Future Research

There is much research needed on the role of teachers diagnosing, mediating and remediating children's problem-solving efforts in computer contexts. There may be value in testing and incorporating some of the ideas of this tutoring in naturalistic settings and for a longer period of time. It is recommended that future researchers investigating children's self-regulation might utilize a combination of quantitative and qualitative analysis to give both a rich and sophisticated account of what has taken place before, during and after mediation. Continued research is needed to address more subtle and affective teacher behaviors, such as laughter, motivation, rapport, the use of touch and body distance, tone and amount of questioning, and teacher control, which are coherently linked to specific research questions within a specific context. The investigation of these behaviors may be the hidden agenda that needs further attention in understanding the mediational process and how it affects children's self-regulation.

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Table 1

Definitions and Examples of Teacher Behaviors and Treatment Components for Four Treatment Groups

Descriptive Definitions	Treatments: Prior Access No Analy	Prior Access Analy	During Access No Analy	During Access Analy
*** Look-back:** Teacher suggestion that child look at model; verbal only (e.g. "Looking at the whole picture will help you remember where the pieces in the puzzle belong").	X	X		
***Contingent Look-back:** Teacher suggestion that child look at model contingent on child's error. Implicit or explicit utterances of model or actual demonstration (e.g. "Do you remember what you do when you want to see where the next puzzle piece belongs?" This is a good time to look at the model".			X	X
****Picture Analysis:** Global analysis describing picture puzzle, including characters' physical characteristics, clothing, objects; descriptions of shape, space, color, line, size (e.g. "Freida has red, curly hair." "There are white, fluffy clouds at the top of the picture").		X		
Contingent Picture Analysis: Statements describing a segment of the picture puzzle in which child is having difficulty.				X
Indexing: Pointing at model with global analysis.				X
Contingent Indexing: Pointing to model or picture segment during picture analysis.				X

Descriptive Definitions	Treatments: Prior Access No Analy	Prior Access Analy	During Access No Analy	During Access Analy
Spatial References: Statements referencing puzzle piece location in model and computer cursor in puzzle space of the dissected puzzle (e.g. "We're looking for this part of the picture". "Where is the space with the small white box?" "Where was the last piece?").				X
+Reflective Assessments: Statements focusing child's attention to the functional significance of actions, suggesting appropriate means used in reaching goal. Used with successful piece placement, to partially completed puzzle and to completed puzzle (e.g."Now the cloud is exactly in the same place in both the puzzle and the picture".)				X
Positive Reinforcements Statements which reinforce child's success of each piece placement (e.g."Good").	X	X	X	X
++Assistance: Teacher assisted piece placement with implicit or explicit utterances or demonstration (e.g. "What do you think about this one?" "Let's try this one".	X	X	X	X

Note. Analy = Analysis

* These codes and definitions were adapted for the purposes of this study from Wertsch et al. 1980; Wood et al. 1978.

** This code and definition was adapted for the purposes of this study from Brookes, 1986; Moss, 1983.

\+ This code and definition was adapted for the purposes of this study from Wertsch et al. 1987.

++ This code and definition was adapted for the purposes of this study from Emihovich et al. 1985.

Table 2

Definitions of Children's Behaviors During Treatment and in Posttests

Component	Definition	Measurement
Self-regulated piece placement	Piece placement without adult encouragement	Discrete, interval scale; values possible: 0-16
Children with self-regulated look-backs	Children who looked back without adult encouragement	Number of children with 1 or more self-regulated look-backs
Children with piece retrieval after self-regulated look-back	Children with piece retrieval after look-back without adult engagement	Number of children who retrieved piece(s) after self-regulated-look-back(s)
Auxiliary Measures:		
Test time	Time to complete tests	Minutes and seconds
Trials	Number of trials to complete puzzle	Discrete, interval data
Strategy type	Type of strategy employed in solving puzzle; trial & error, mixed and model-consultation	Number of children in each strategy type

Table 3

Children's Look-back Behaviors Assessed in Pretest

Prior Access		During Access		Access	Analy	Access x Analy
No Analy	Analy	No Analy	Analy			
[a]7 (50)	4 (23)	5 (33)	2 (13)	[b]1.08	3.74*	1.58

Note. Analy = Analysis
[a]Number of cases in each group with one or two self-regulated look-backs; proportions supplied in parentheses. [b]Significance assessed by chi-square tests, df = 1,N = 61.

* $p < .05$.

Table 4

Means, Standard Deviations, and F-ratios for Teacher Behaviors Assessed During Treatment

Measure	Prior Access No Analy (n=14)	Prior Access Analy (n=17)	During Access No Analy (n=15)	During Access Analy (n=15)	Access	Analy	Access x Analy
Look-Back	[a].21 (.58)	.82 (1.59)	6.67 (3.84)	9.13 (3.20)	120.75***	5.10**	1.88
Picture Analy	.21 (.43)	19.50 (1.77)	.67 (1.59)	24.00 (14.0)	1.98	136.96***	1.22
Index	.14 (.36)	.94 (.24)	.46 (.52)	1.00 (.00)	4.64**	60.31***	2.37
Spatial Ref	.85 (1.61)	.82 (1.28)	1.87 (2.20)	7.60 (2.61)	63.02***	30.70***	32.18***
Reflect Assess	.00 (.00)	.00 (.00)	.20 (.56)	4.67 (5.19)	14.65***	11.04**	11.30***
Pos Reinf	12.29 (3.56)	11.94 (3.91)	12.73 (2.05)	12.00 (4.27)	.07	.34	.04
Assist	4.64 (3.83)	3.47 (3.10)	2.93 (2.76)	3.00 (3.14)	1.65	.46	.56

Note. Analy = Analysis; Ref = Reference; Reflect Assess = Reflective Assessments; Pos Reinf = Positive Reinforcements; Assist = Assistance.

[a]Means and standard deviations in parentheses; ANOVA, df = 1 for access, 1 for analysis, 1 for access x analysis, df = 57 within.

** $p < .01$.

*** $p < .001$.

Table 5

Means, Standard Deviations, F-ratios and Chi-square Values of Children's Learning Behaviors Assessed During Treatment

Measure	Prior Access No Analy (n=14)	Prior Access Analy (n=17)	During Access No Analy (n=15)	During Access Analy (n=15)	Access	Analy	Access x Analy
SR Piece	[a]11.35 (3.83)	11.47 (4.29)	12.07 (4.30)	13.00 (3.14)	1.27	.26	.16
SR Look	[b]7 (50)	4 (23.5)	8 (53.3)	9 (60)	2.75*	.75	1.59
Look/Piece: [c]					6.96*	1.20	2.67
No look	7 (50)	13 (76.5)	7 (46.7)	6 (40)			
Look No Piece	7 (50)	3 (17.6)	4 (26.7)	5 (33.3)			
Look & Ret ≥ 1 piece	0 (0)	1 (5.9)	4 (26.7)	4 (26.7)			

Note. Analy = Analysis; SR Piece = Self-regulated piece placement; SR Look = self-regulated look-back; Look/Piece = piece retrieval and look-back; Look & Ret ≥ 1 piece = children who retrieved one or more pieces after self-regulated look-back. [a]Mean and standard deviation in parentheses. F-ratios; ANOVA, df = 1 for access, 1 for analysis, 1 for access x analysis, df = 57 within. [b]Number of cases in each group with one or more look-backs; proportions in parentheses. Chi-square, df = 1,N = 61). [c]Number of cases in each group; proportions in parentheses. Chi-square, df = 2,N = 61).

* $p < .05$.

Table 6

Means, Standard Deviations, F-ratios and Chi-square Values of Children's Behaviors Assessed in Immediate Posttest

Measure	Prior Access No Analy (n=14)	Prior Access Analy (n=17)	During Access No Analy (n=15)	During Access Analy (n=15)	Access	Analy	Access x Analy
SR Piece	[a]12.50 (3.10)	12.00 (4.11)	12.47 (5.00)	12.40 (3.72)	.04	.12	.14
SR Look	[b] 3 (21.4)	4 (23.5)	11 (73.3)	8 (53.3)	10.35***	.72	.93
Look/piece:					11.31**	.79	1.21
No Look	[c]11 (78.6)	13 (76.5)	4 (26.7)	7 (46.7)			
Look No Piece	3 (21.4)	3 (17.6)	7 (46.7)	5 (33.3)			
Look & Ret $\geq$ 1 piece	0 (0)	1 (5.9)	4 (26.7)	3 (20.0)			

Note. Analy = Analysis; SR Piece = Self-regulated piece placement; SR Look = self-regulated look-back; Look/Piece = piece retrieval after self-regulated look-back; Look & Ret $\geq$ 1 piece = children who retrieved one or more pieces after self-regulated look-back.
[a]Mean and standard deviation in parentheses. F-ratios; ANOVA, df = 1 for access, 1 for analysis, 1 for access x analysis, df = 57 within. [b]Number of cases in each group with one or more look-backs; proportions in parentheses. Chi-square, df = 1,N = 61. [c]Number of cases in each group; proportions in parentheses. Chi-square, df = 2,N = 61.

** $p < .01$.
*** $p < .001$.

Table 7

Means, Standard Deviations, F-ratios and Chi-square Values of Children's Behaviors Assessed in Delayed Posttest

Measure	Prior Access No Analy (n=14)	Prior Access Analy (n=17)	During Access No Analy (n=15)	During Access Analy (n=15)	Access	Analy	Access x Analy
SR Piece	[a]13.50 (1.74)	12.76 (3.15)	12.47 (3.76)	12.60 (2.88)	1.69	.00	.13
SR Look	[b]2 (14.3)	7 (41.2)	8 (53.3)	12 (80.0)	8.66**	3.78*	8.40**
Look-back/piece:					8.66**	3.91	8.51**
No Look	[c]12 (85.7)	10 (58.8)	7 (46.7)	3 (20.0)			
Look No Piece	2 (14.3)	3 (17.6)	4 (26.7)	7 (46.7)			
Look & Ret ≥ 1 piece	0 (0)	4 (23.5)	4 (26.7)	5 (33.3)			

Note. Analy = Analysis; SR Piece = Self-regulated piece placement; SR Look = self-regulated look-back; Piece/Look-back = Piece retrieval after self-regulated look-back; Look & Ret ≥ 1 piece = children who retrieved one or more pieces after self-regulated look-back.

[a]Mean and standard deviation in parentheses. F-ratios; ANOVA, df = 1 for access, 1 for analysis, 1 for access x analysis, df = 57 within. [b]Number of cases in each group reporting presence of one or more look-backs; proportions supplied in parentheses. Chi-square, df = 1,N = 61). [c]Number of cases in each group reporting presence of one or more pieces retrieved from self-regulated look-back; proportions supplied in parentheses. Chi-square df = 2,N = 61).

* $p < .05$.

** $p < .01$.

Table 8

Post hoc Analyses in Immediate Posttest

Measure	Prior Access No Analy (n=14)	Prior Access Analy (n=17)	During Access No Analy (n=15)	During Access Analy (n=15)	Access	Analy	Access x Analy
Test Time	[a]4.36 (2.17)	4.35 (2.26)	4.87 (2.07)	6.00 (3.52)	2.17	1.54	.00
Trials	[a]55.43 (20.51)	54.88 (22.35)	50.13 (18.22)	50.00 (18.68)	1.23	.00	.00
Strategy Types:					9.78**	5.15*	9.82**
Trial Error	[b]13 (92.9)	14 (82.4)	8 (53.3)	7 (46.7)			
Mixed	1 (7.1)	2 (11.8)	7 (46.7)	4 (26.7)			
Model-Consult	0 (0)	1 (5.9)	0 (0)	4 (26.7)			

Note. Analy = Analysis; Model-Consult = model-consultation.
[a]Mean and standard deviation in parentheses. F-ratios; ANOVA, df = 1 for access, 1 for analysis, 1 for access x analysis, df = 57 within. [b]Number of cases in each group; proportions in parentheses. Chi-square, df = 2,N = 61.

* $p < .05$.
** $p < .01$.

Table 9

Post hoc Analyses in Delayed Posttest

Measure	Prior Access No Analy (n=14)	Prior Access Analy (n=17)	During Access No Analy (n=15)	During Access Analy (n=15)	Access	Analy	Access x Analy
Test Time	[a]3.93 (1.73)	5.71 (4.78)	5.60 (2.85)	6.20 (3.63)	.01	.00	.03
Trials	[a]53.07 (22.44)	53.59 (17.61)	49.00 (17.87)	48.27 (16.10)	.01	.82	2.69
Strategy Types:					12.10**	9.61**	13.78***
Trial Error	[b]14 (100)	11 (64.7)	9 (60)	3 (20)			
Mixed	0 (0)	5 (29.4)	2 (13.3)	7 (46.7)			
Model-Consult	0 (0)	1 (5.9)	4 (26.7)	5 (33.3)			

Note. Analy = Analysis; Model-Consult = model-consultation. [a]Mean and standard deviation in parentheses. F-ratios; ANOVA, df = 1 for access, 1 for analysis, 1 for access x analysis, df = 57 within. [b]Number of cases in each group reporting presence of one or more look-backs; proportions supplied in parentheses. Chi-square, df = 2,N = 61).

** $p < .01$.
*** $p < .001$.

Table 10

Intercorrelations Among Four Variables, Immediate Posttest

Variables	1	2	3	4
1. SR Piece	-	-.50***	.54***	-.06
2. Test Time	-	-	-.40***	.32**
3. Trials	-	-	-	-.13
4. SR Look	-	-	-	-

Intercorrelations Among Four Variables, Delayed Posttest

Variables	1	2	3	4
1. SR Piece	-	-.63***	.40***	-.16
2. Test Time	-	-	-.37***	.67***
3. Trials	-	-	-	-.24*
4. SR Look	-	-	-	-

Note. SR Piece = self-regulated piece placement; SR Look = self-regulated look-back.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 11

Means, Standard Deviations, F-ratios of Self-regulated Piece Placements, Test Time and Trials by Strategy Differences

Measure	Trial & Error (n = 42)	Mixed (n = 14)	Model (n = 5)	F
Immediate Posttest				
SR Piece	[a]12.33 (3.58)	13.71 (3.62)	8.40 (5.94)	3.60*
Test Time	4.50 (2.38)	4.79 (1.53)	8.40 (4.28)	5.88**
Trials	56.02 (19.76)	49.35 (18.70)	33.40 (9.34)	3.45*
Delayed Posttest				
	(n = 37)	(n = 14)	(n = 10)	
SR Piece	13.03 (2.82)	13.79 (2.57)	10.70 (3.13)	3.75*
Test Time	4.24 (1.99)	4.79 (2.48)	10.50 (4.69)	21.25***
Trials	55.49 (18.99)	48.14 (17.20)	38.60 (8.96)	3.96*

Note. SR Piece = Self-regulated piece placement.
[a]Mean and standard deviation in parentheses. df = 2,58.

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Example of Experimental Task